Journal of Forestry Research (2014) 25(3): 591–596
DOI 10.1007/s11676-014-0452-3

ORIGINAL PAPER

Plant diversity at Chilapatta Reserve Forest of Terai Duars in sub-humid tropical foothills of Indian Eastern Himalayas

Gopal Shukla • Rajib Biswas • A. P. Das • Sumit Chakravarty

Received: 2012-08-04; Accepted: 2013-03-04

Abstract: From March 2007 to March 2009 we quantified plant diversity at Chilapatta Reserve Forest in Terai Duars in the Indian eastern Himalayas. We sampled stratified random nested quadrats. Species richness was 311, representing 167 genera and 81 families. The species diversity index and concentration of dominance of the forest were 2.20 and 0.0072, respectively. Shannon-Wiener index and evenness indices were 4.77 and 1.44, respectively. The Importance Value Index (IVI) of species ranged from 0.13 to 37.94. The estimated diversity indices indicated heterogeneity of the forest in its composition, structure, function and dynamics. Rich forest plant diversity supports the need for continued conservation of tropical forests.

Keywords: Terai Duars, phyto-sociology, plant diversity, diversity indices

Introduction

Global efforts are increasing to identify, conserve and sustainably use biodiversity in natural forests. Forests are essential for human survival, socio-economic wellbeing and for ecosystem function and stability (Singh 2002; Gardner et al. 2009). Knowledge of floristic composition, biodiversity and phytomass supports understanding of forest ecosystem dynamics and the utility of forest resources (Gentry 1990; Hartshorn 1990). Tropical forests are highly diverse due to species interactions and niche variation that result from favorable climatic and edaphic conditions (Ojo and Ola-Adams 1996; Reddy et al. 2007). Large scale destruction of forests has resulted in environmental and economic problems (Kareiva et al. 2007; Bradshaw et al. 2009; Anonymous 2010a, 2011). Data on structure and functional dynamics of forest vegetation are scarce in India (Parthasarathy and Sethi 1997; Reddy et al. 2007). Quantitative plant diversity inventories are reported from the forests of the Western Ghats but reports are fewer for the Eastern Ghats (Reddy et al. 2007) and the Indian region of the Indo-Malayan Biodiversity Hot Spot. Studies of these areas have been few (Banerjee et al. 1986; Khan et al. 1997; Tiwari et al. 1998; Jamir and Pandey 2002; Sharma et al. 2002; Kumar et al. 2006; Devi and Yadava 2009). Terai Duars in West Bengal, India is located in the sub-humid tropical foothills of the eastern Himalayas. It is one of the important areas of the Indo-Malayan Biodiversity Hot Spot (Myers and Mittermeier 2000). Chilapatta Reserve Forest is one of the most biodiverse areas of the Duars (Anonymous 2001). Forest types in the Duars range from tropical wet evergreen to tropical moist deciduous (Champion and Seth 1968). Scientific management of forests in India, especially in Chilapatta, is complicated by lack of understanding of structural and functional relationships of forest ecosystems (Pande 2001). Careful and systematic studies are lacking for vegetation and climax vegetation fragments such as the forests at Chilapatta. The present study was undertaken to understand the diversity of forest vegetation. Our objective was to develop a foundation for natural resources management and conservation of these floristically rich patches.

Materials and methods

The study was conducted from March 2007 to March 2009 at Chilapatta Reserve Forest under Cooch Behar Wildlife Division whose total area was about 41 ha (Anonymous 2001). The forest is located at northern fringe of the state in foothills of sub-Himalayan mountain belts. Latitude, longitude and elevation of the study area were 26°32.85′ N, 89 22.99′ E and 47 m a.s.l.,

The online version is available at http://www.springerlink.com

Gopal Shukla (✉), Sumit Chakravarty
Department of Forestry, Uttar Banga Krishi Viswavidyalaya, Pundibari-736165 (Cooch Behar) West Bengal, India.
Email: gopalshukla12@gmail.com; c_drsumit@yahoo.com

Rajib Biswas • A. P. Das
Department of Botany, University of North Bengal, Siliguri (West Bengal) India.

Corresponding editor: Hu Yanbo

respectively. The forest soil was acidic, high in organic carbon and available nitrogen, medium in phosphorus and potash. The soil structure at 0−30 cm depth was 70% sand, 19% silt and 11% clay (Paul 2004). The climate is moist tropical (Anonymous 2001). Annual rainfall averages 2942.40 mm, with 80% of it falling during June-August. Mean monthly relative humidity ranged from 69.0%−91.5%. Summer and winter temperatures are mild, highest at 32°C in May and lowest at 8.9°C in January (Anonymous 2010b).

We used stratified random nested quadrat sampling to analyze vegetation composition. We sampled quadrats of 20 m × 20 m for trees and lianas (57 quadrats). Within these 400 m^2 quadrats we sampled two 5 m × 5 m quadrats at the diagonal corners for shrubs and climbers (114 quadrats), and five 1 m × 1 m quadrats (285 quadrates), four at the corners and one at the center of each 20 m × 20 m quadrat, for herbs and ferns. Identification of the specimens was done in the field as far as possible. Unidentified specimens were taken for identification either to the Taxonomy and Environment Biology Laboratory, Department of Botany, University of North Bengal, Siliguri or to the National Herbarium, Shibpur Howrah. We calculated Raunkiaer's frequency, density, basal area and importance value index (IVI) following standard methods (Raunkiaer 1934; Cintron and Novelli 1984; Chauhan et al. 2009). Commonly used diversity indices such as species richness, species diversity index (Menhinick 1964), concentration of dominance (Simpson 1949), Shannon-Wiener diversity index (Shannon and Weiner 1963) and species evenness index (Pielou 1975) were used to analyze the plant diversity of the forest.

Results

Diversity indices

A total of 311 plant species were recorded but 52 of these could not be identified (Appendix 1). Identified species represented 85 families and 167 genera. Tree, shrub, herb, climber, liana, and fern species richness were 160, 36, 49, 44, 4 and 19, respectively (Appendix 1). Species diversity index, concentration of dominance, Shannon-Wiener index and evenness estimated were 2.20, 0.0072, 4.77 and 1.44, respectively (Table 1).

Table 1: Diversity indices of plant communities at Chilapatta Reserve Forest**.**

Life forms	S	D′	C	H′	EI	D
Tree	160	2.07	0.018	4.70	1.43	2615
Shrub	36	0.73	0.037	2.87	1.49	8512
Herb	49	0.62	0.028	4.46	2.27	7628
Climber	43	0.92	0.038	1.26	1.40	775
Liana	4	0.27	0.075	0.55	3.55	106667
Fern	19	0.34	0.310	1.57	2.49	218982
Forest	311	2.20	0.0072	4.77	1.44	-

S - Species richness, D′ - Species diversity index, C - Concentration of dominance, H′ - Shannon-Wiener index, EI-Evenness index, D - individuals ha^{-1}

Vegetation analysis

Raunkiaer's frequency, density, IVI and basal area are listed in Appendix 1. The forest was grouped into A, B and C frequency classes following Raunkiaer's law of frequency distribution (Raunkiaer 1934). In the three classes, there were 77.49%, 20.90% and 1.61% of species, respectively (Fig. 1), whereas in Raunkiaer's normal frequency the distribution was 53%, 14%, 9%, 8% and 18% of species in frequency classes A, B, C, D and E, respectively. The pattern of distribution across frequency classes was similar to that described in the law as A > B > C. But unlike the law, which described five classes, this forest had only three classes. Trees were included in all the three classes. Shrubs and climbers were included in classes A and B only. Herbs, lianas and ferns were included only in class A. Density of the species ranged from 0.44 to 13,404 individuals·ha^{-1}. Tree, shrub, liana, climber, fern and herb densities were estimated as 2615, 8512, 775, 7628, 106667, and 218982 plants ha^{-1}, respectively.

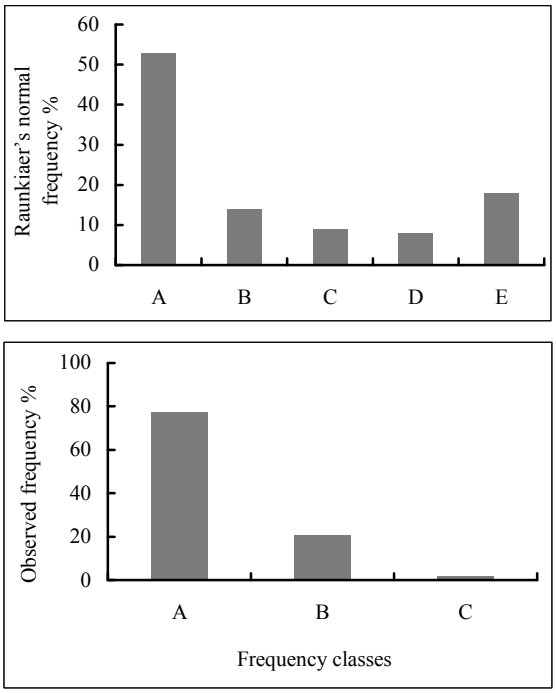

Fig. 1: Comparison of Raunkiaer's normal frequency distribution of species with observed frequency distribution of species in the forest**.**

IVI of species in the forest ranged from 0.13 to 37.94. The most important tree species was *Tectona grandis* with highest IVI of 8.74 followed by *Pterygota alata* at 8.00. Other important trees species were *Lagerstroemia parviflora* (7.28), *Actinodaphne obovata* (6.09), *Actinodaphne sikkimensis* (5.47), *Shorea robusta* (3.96) and *Gmelina arborea* (3.37). Basal area ranged from 0.25−41.60 m^2·ha^{-1}, the highest for *Ficus religiosa* and lowest for *Curculigo orchiodes*. Basal areas for some important timber species such as *Shorea robusta*, *Tectona grandis*, *Michelia champa*, *Gmelina arborea* and *Lagerstroemia parviflora* were 27.56, 24.39, 17.80, 15.57 and 15.46 m^2·ha^{-1}, respectively. The

overall basal area estimated was 522.91 $m^2 \cdot ha^{-1}$.

Discussion

Diversity indices

Species richness of 311 species recorded in the present study indicates that the forest is rich in plant diversity. The total unit area species richness in the forest is 136 species/ha (trees- 70 species/ha; shrubs- 126 species/ha; herbs- 1719 species/ha; climbers and lianas- 20 species/ha; ferns- 667 species/ha). The species diversity index considers the total number of species and total number of individuals of all the species. Based on this index it can be stated that though the tree species found in this forest were more diverse but are rarer or less frequently present than other vegetation forms (Kumar et al. 2006). The forest also has higher evenness values which indicate that the plant species were evenly distributed in its community (Newaz 2006). Concentration of dominance reflects the number of chance a species is encountered during sampling. Lower value of 0.0072 indicates the high chances of encountering a species in this forest. This can be attributed to sharing of dominance by more than one species in the forest (Dash et al. 2009). Very low concentration of dominance estimated was accordance with higher diversity and related inversely to the index of dominance (Odum 1971). Conversely, Shannon-Wiener index that determine diversity was estimated high. It was also inversely proportional to concentration of dominance (Galav et al. 2005; Dash et al. 2009). This index is also an expression of community structure and complexity of a habitat. A high index value indicates that this forest has high plant diversity and stable communities.

Vegetation analysis

Analysis of Raunkiaer's frequency classes revealed that most of the species had low frequency as would be expected in typical species-abundance distributions in tropical forests (Odum 1971). The distribution pattern of species in frequency classes indicates that the Raunkiaer's law of frequency distribution holds good for this forest also. However this forest had only three classes instead of five as described in the law. This was due to its higher heterogeneous nature and deviation from the normal frequency distribution as described by Raunkiaer (1934). Moreover, the trend of species falling in the frequency classes indicates that herbs, lianas and ferns were more heterogeneous than the shrubs, climbers and trees. A community is considered homogenously distributed when the number of individuals is same in all parts of an area. Decreasing number of species in successive frequency class intervals but an increase in the 80%−100% class interval has been widely interpreted as a fundamental community characteristics indicating homogeneity (McIntosh 1975). Contrary to this, in the present study the forest exhibited reverse trend showing heterogeneity. Further, the species with poor dispersion of frequencies were higher in number than the number of species with high frequency values. High IVI values clearly indicate the ecological importance of corresponding species. IVI helps in understanding the ecological significance of a species in its community/habitat. Higher the IVI more ecological significance of the species is in a particular ecosystem (Odum 1971). Information on distribution patterns and IVI would be of prime importance in deciding the management options for specific host population of native wildlife that is facing the danger of local extinction due to heavy human pressure surrounding this forest.

Evaluation of density-dependent status of a species in a study site is important for conservation and management of forests (Odum 1971). In this stuffy, the tree density and basal area estimated is higher than the estimates reported (Campbell et al. 1992; Kumar et al. 2006). Density of trees in tropical forests ranges from a low value of 245 individuals/ha (Richards 1996), to intermediate values of 420−617 in Brazilian Amazon (Campbell et al. 1992) and to a high value of 639−713 or even higher in Central Amazonian upland forest (Campbell et al. 1992; Ferreira and Prance 1998). These parameters vary with forest community type, forest age class, tree species and size class, site history, site condition and other factors (Kumar et al. 2006). Higher tree density and basal area was due to high tree species richness and favourable climatic conditions prevailing in study area. Favourable climatic conditions supported higher species richness and growth rates that were reflected to higher basal area (Kumar et al. 2006). Moreover, lesser disturbance in Reserve Forest owing to its protection from the law also contributed to the increase in density and basal area of the trees.

Conclusion

Chilapatta Reserve Forest supports a diverse plant community. The rich plant diversity is worthy of continued conservation. It is useful to rank/order forests by species richness, diversity, density and basal area. In so doing, this forest may rank as one of the most diverse and densest in the world. The rarer species need proper attention to determine their conservation status and key functions. Mapping concentration areas of species and study of their key ecological and cultural functions would help identify locations for conservation actions. Forest managers can use the information to manage the forest for wildlife and for its cultural resource values. The parameters like density, basal area, IVI and diversity indices can act as indicators of changes and susceptibility to anthropogenic stressors (Kumar et al. 2006).

References

Anonymous. 2001. *4th Working Plan for the Forests of Cooch Behar district and Jalpaiguri district (Part) Comprising Cooch Behar Forest Division and Cooch Behar S. F. Division*. Volume I, 2000-01 to 2009-10. Darjeeling: Divisional Forest Officer, Working Plans (North) Division, p.180.

Anonymous. 2010a. Global Forest Resources Assessment 2010: Main Report. FAO Forestry Paper 163. Rome, Italy, p.340.

Anonymous. 2010b. Metrological Annual Report. Tobacco Regional Research Centre, Dinhata, Cooch Behar (West Bengal). p.53.

Anonymous. 2011. State of the World's Forest. Rome: FAO, p.163.

Ashton PS. 1964. A quantitative phytosociological techniques applied to tropical mixed rainforest vegetation. *Malaysia Forestry,* **27**: 304−307.

Banerjee SK, Nath S, Banerjee SP. 1986. Phytosociology and soil characteristics of forests in eastern Himalayas. *Indian Journal Tropical Agriculture,* **4**: 116−125.

Bradshaw CJA, Sodhi NS, Brook BW. 2009. Tropical turmoil: a biodiversity tragedy in progress. *Front Ecol Environ,* **7**: 79−87.

Campbell DG, Stone IL, Rosas AJr. 1992. A comparison of phytosociology and dynamics of three flood plains (Varzea) forests of known age, Rio Jurua, Western Brazilian Amazon. *Bot J Linn Soc,* **108**: 213−237.

Champion HG, Seth SK. 1968. *A Revised Survey of the Forest Types of India*. New Delhi: Manager of Publications, p.404.

Chauhan SK, Gupta N, Ritu Yadav S, Chauhan R. 2009. Biomass and carbon allocation in different parts of agroforestry tree species. *Indian Forester,* **135**: 981−993.

Cintron G, Novelli YS. 1984. Methods for studying mangrove structure. In: *The* Mangrove Ecosystem Research Methods (Eds. Snedaker, C. and Snedaker, G.), UNICSO. 251p.

Dash PK, Mohapatra PP, Rao YG. 2009. Diversity and distribution pattern of tree species in Niyamgiri hill ranges, Orissa, India. *Indian Forester,* **135**: 927−942.

Devi LS, Yadava PS. 2009. Aboveground biomass and net primary production of semi-evergreen tropical forest of Manipur, north-eastern India. *Journal of Forestry Research,* **20**: 151−55.

Ferreira LV, Prance GT. 1998. Species richness and floristic composition in four hectares in the Jau National Park in upland forests in Central Amazonian. *Biodiversity Conservation,* **7**: 1349−1364.

Galav PK, Katewa SS, Chaudhary BL, Jain A. 2005. Phytosociological studies on the grassland community of southern Aravalli hills of Rajasthan. *Indian Forester,* **131**: 493−952.

Gardner TA, Barlow J, Chazdon R, Ewers RM, Harvey CA, Peres CA, Sodhi NS. 2009. Prospects for tropical forest biodiversity in a human-modified world. *Ecology Letters,* **12**: 1−21.

Gentry AH. 1990. Floristic similarities and differences between southern Central America and Upper and Central Amazonia. *In*: Gentry, A. H. (ed.), *Four Neotropical rainforests*. New Haven, USA: Yale University Press, pp. 141−157.

Hartshorn GS. 1990. An overview of Neotropical forest dynamics. In: Gentry, A. H. (ed.), *Four neotropical rainforests*. New Haven, USA: Yale University Press, pp. 585−599.

Jamir SA, Pandey HN. 2002. Status of biodiversity in the sacred groves of Jaintia hills, Meghalaya. *Indian Forester,* **128**: 738−44.

Kareiva P, Watts S, McDonald R, Boucher T. 2007. Domesticated nature: shaping landscapes and ecosystems for human welfare. *Science,* **316**: 1866−1869.

Khan NL, Menon S, Bawa KS. 1997. Effectiveness of the protected area network in biodiversity conservation, a case study of Meghalaya State. *Biodiversity and Conservation,* **6**: 853−868.

Kumar A, Marcot BG, Saxena A. 2006. Tree species diversity and distribution patterns in tropical forests of Garo hills. *Current Science*, **91**: 1370−1381.

McIntosh RP. 1975. H.A. Gleason 'Individualistic Ecologist' (1882-1975) His contributions to Ecological theory. *Bull Torrey Bot Club,* **102**: 253−273.

Menhinick EF. 1964. A comparison of some species diversity indices applied to samples of field insects. *Ecology,* **45**: 858−861.

Myers N, Mittermeier RA. 2000. Biodiversity hotspots for conservation priorities. *Nature,* **403**: 853−854.

Newaz MS. 2006. Diversity and composition of tree species regeneration in the secondary forests of Chittagong, Bangladesh. *Indian Forester,* **132**: 1419−1428.

Odum EP. 1971. *Fundamentals of Ecology (3rd edn.)*. Philadelphia: WB Saunders Co.,.p.574.

Ojo LO, Ola-Adams BA. 1996. Measurement of tree diversity in the Nigerian rainforest. *Biod Cons*, **5**: 1253−1270.

Pande PK. 2001. Litter nutrient dynamics of *Shorea robusta* Gaertn. plantation at Doon Valley (Uttaranchal), India. *Indian Forester,* **127**: 980−994.

Parthasarathy N, Sethi P. 1997. Tree and liana species diversity and population structure in a tropical dry evergreen forest in south India. *Trop Ecol,* **38**: 19−30.

Paul SC. 2004. Land use effects on soil characteristics of Terai region of West Bengal. M. Sc. Thesis. Uttar Banga Krishi Viswavidyalaya, West Bengal, India. Unpubl. 58p.

Pielou EC. 1975. *Ecological Diversity.* New York: John Wiley and Sons, p.165.

Raunkiaer C. 1934. *The Life Forms of Plants and Statistical Plant Geography*. Oxford, U. K: Oxford University Press, p.632.

Reddy CS, Pattanaik C, Mohapatra A, Biswal AK. 2007. Phytosociological observations on tree diversity of tropical forest of Similipal Biosphere Reserve, Orissa, India. *Taiwania,* **52**: 352−359.

Richards PW. 1996. *The Tropical Rain Forest: An Ecological Study*. Cambridge: Cambridge University Press, p.575.

Shannon CE, Weiner W. 1963. The Mathematical Theory of Communication. Urbana, Illinois, USA: University of Illinois Press, p.111.

Sharma GD, Bhattacherjee S, Sinha M, Das AK. 2002. Status of plant biodiversity of Cachar district and is conservation. *Journal of Economic and Taxonomic Botany*, **26**: 94−1001.

Simpson EM. 1949. Measurement of diversity. *Nature,* **163**: 688.

Singh JS. 2002. The biodiversity crises: a multifaceted review. *Current Science,* **82**: 638−647.

Tiwari BK, Barik SK, Tripathi RS. 1998. Sacred groves of Meghalaya- conserving the sacred for biodiversity management. *In*: Ramakrishnan, P. S., Saxena, K. G. and Chandrashekara, U. M. (eds), *Conserving the sacred groves for biodiversity management*. New Delhi, India: Oxford and IBH Publishing Co., pp. 253−262.

Appendix 1. Quantitative characters of plant communities at Chilapatta Reserve Forest

Family	Scientific name	1	2	3	4	Family	Scientific name	1	2	3	4
Acanthaceae	*Phlogacanthus thysiformis*	A	2526.3	1.2	-	Dracaenaceae	*Dracaena angustifolia*	B	98.2	0.8	-
	Rungia pectinata	A	2631.5	1.1	-	Drynariaceae	*Drynaria propinqua*	A	396.5	2.3	-
Anacardiaceae	*Drymicarpus racemosus*	A	10.1	0.8	4	Dryopteridaceae	*Dryopteris sikkimensis*	A	3052.6	1.2	-
	Saurindia madagascarensis	A	11.8	0.7	4.2	Ehretiaceae	*Ehretia acuminata*	A	14.9	1	1.4
	Miliusa roxburghiana	A	178.9	1.3	-	Elaeocarpaceae	*Sloania Sterculiaceae*	B	11	0.7	2.3
Annonaceae	*Uvaria hamiltonii*	A	16.2	0.9	3.3		*Elaeocarpus lanceifolius*	A	15.8	1	2.6
	Polyalthia simiarum	B	19.3	1.1	1.4		*Antidesma acidum*	A	98.2	0.9	-
Alangiaceae	*Alangium chinense*	B	214	1.6	-		*Baliospermum montanum*	A	7.9	0.5	3
	Alstonia scholaris	A	9.2	0.7	2.5		*Croton caudatus*	A	14.5	0.9	1.2
	Chonemorpha fragrans	A	477.2	2.7	-		*Macaranga denticulata*	B	35.1	2	4.6
	Ichnocarpus frutescens	A	463.2	2.5	-	Euphorbiaceae	*Macaranga indica*	B	23.7	1.4	4
	Ichnocarpus volubilis	B	722.8	4	-		*Mallotus philippensis*	B	28.1	1.6	7.9
Apocynaceae	*Tabernaemontana spp.*	A	112.3	0.9	-		*Phyllanthus reticulatus*	B	15.8	1	1.2
	Tabernaemontana divaricata	A	84.2	0.8	-		*Sapium baccatum*	B	20.2	1.2	S
	Vallaris solanacea	A	207	1.3	-		*Trewia nudiflora*	A	17.1	1.1	19.8
	Wrightia arborea	B	9.2	0.6	5.1		*Ricinus communis*	A	308.8	1.9	-
	Wrightia tomentosa	A	15.3	0.9	6.3		*Albizia lucidior*	B	25	1.5	11.7
	Amorphophallus bulbifer	A	3684.2	1.4	-		*Bauhinia vahlii*	B	24.6	1.3	-
	Pinangra gracilis	A	3.95	0.4	0.4		*Bauhinia variegata*	B	20.2	1.2	11.3
	Calamus erectus	A	1.7	0.3	-		*Bauhinia scandens*	B	8.3	0.5	5.2
	Calamus guruba	A	1.7	0.3	-		*Dalbergia stipulacea*	A	12.3	0.7	13.8
Arecaceae	*Colocasia esculenta*	A	4912.3	1.7	-		*Desmodium gangeticum*	A	143.9	1	-
	Pothos catheartii	A	126.3	18.4	-		*Desmodium heterocarpon*	A	178.9	1.2	-
	Pothos scandens	A	312.3	34.2	-		*Desmodium styracifolium*	A	319.3	1.9	-
	Rhaphidophora calophylla	A	2175.4	1	-		*Desmodium triquetrum*	B	456.1	2.6	-
	Rhaphidophora glauca	A	4561.4	1.7	-		*Mimosa pudica*	A	2	5.3	-
	Rhaphidophora hookeri	A	2561.4	1.1	-	Fabaceae	*Pterocarpus marsupium*	A	13.2	0.9	5.9
	Acmella calva	A	9193	2.9	-		*Butea parviflora*	A	4.4	0.4	1.4
	Ageratum conyzoides	A	3543.9	1.5	-		*Tephrosia candida*	A	12.7	0.8	6.2
Asteraceae	*Eupatorium odoratum*	B	0.8	3.6	-		*Acacia lenticularis*	B	10.5	0.6	6.6
	Elepanthropus scaber	B	6175.4	2.2	-		*Albizia chinensis*	A	8.3	0.7	10.7
	Mikania micrantha	A	98.2	0.8	-		*Celastrus paniculatus*	B	143.9	0.9	-
Athyriaceae	*Diplazium esculentum*	B	93	34.6	-		*Albizia lebbeck*	A	14.9	0.8	11.9
Bignoniaceae	*Oroxylum indicum*	A	11.4	0.7	5		*Albizia procera*	A	1.7	0.3	3.5
Bombacaceae	*Bombax ceiba*	B	7.9	0.6	19.4		*Bridelia sikkimensis*	A	14	0.8	2.6
Boraginaceae	*Cordia oblique*	A	3.9	0.3	2.6		*Dalbergia latifolia*	B	17.1	1	10
Burseraceae	*Canarium sikkimense*	A	11.8	0.8	2.2		*Acacia concenna*	A	1.3	0.2	2.6
	Capparis multiflora	A	11.8	0.9	2.4		*Castanopsis indica*	A	18.9	1.3	3.2
Capparidaceae	*Capparis sikkimensis*	A	7.5	0.4	3.2	Fagaceae	*Castanea indica*	B	10.5	0.7	4.4
	Stixis suaveolens	A	13.2	0.8	1.8		*Quercus Castanopsis*	A	3.9	0.4	17.8
Chloranthaceae	*Chloranthus sp*	A	2807	1.2	-	Flacourtiaceae	*Gynocardia odorata*	A	7	0.5	1.7
	Termenalia bellirica	A	26.7	1.5	11.8	Gesneriaceae	*Aeschynanthus acuminatus*	A	231.6	1.4	-
	Terminalia chebula	B	24.6	1.4	7.9	Helminthostachyaceae	*Helminthostachys zeylanica*	A	2491.2	1	-
Combretaceae	*Terminalia crenulata*	B	5.7	0.5	4.9	Hypoxidaceae	*Curculigo orchiodes*	A	13.2	0.9	0.2
	Terminalia myriocarpa	B	13.2	0.8	6.3		*Curculigo sp.*	A	3.9	0.3	0.4
	Termenalia tomentosa	B	34.2	2.1	15.6		*Gomphostemma ovate*	A	1.2	4	-
Commelinaceae	*Floscopa scandens*	A	1859.6	1	-	Lamiaceae	*Plectranthus barbatus*	A	112.3	0.9	-
	Murdannia nudiflora	A	1333.3	0.9	-		*Pogostemon benghalensis*	A	807	0.5	-
Convolvulaceae	*Ipomoea hirta*	A	98.2	0.8	-		*Actinodaphne obovata*	A	31.6	1.7	6.1
	Porana paniculata	A	77.2	0.6	-		*Actinodaphne sikkimensis*	A	24.6	1.9	5.5
Convallariaceae	*Ophiopogon wallichianus*	A	9929.8	3	-		*Beilschmiedia dalzellii*	A	8.3	0.6	2.9
	Hodgsonia macrocarpa	A	133.3	0.9	-		*Cinnadenia paniculata*	A	6.6	0.5	7.9
Cucurbitaceae	*Momordica charantia*	A	119.3	0.8	-		*Cinnamomum bejolghota*	B	14	0.9	5.7
	Mucia maderaspatane	A	84.2	0.6	-		*Litsea cubeba*	A	12.7	0.8	5
	Cyperus cuspidatus	A	11017.5	3.1	-		*Litsea glutinosa*	A	29.8	1.8	4.4
Cyperaceae	*Cyperus rotandus*	A	4035	1.4	-	Lauraceae	*Litsea hookeri*	A	30.7	2	4.1
	Cyperus sp.	A	3614	1.4	-		*Litsea lacta*	B	24.1	1.4	4.7
	Scleria terrestris	A	207	1.4	-		*Litsea monopetala*	B	29.8	1.5	4
	Dillenia indica	A	15.3	1	14.7		*Litsea panamanja*	B	33.8	1.9	4
Dilleniaceae	*Dillenia pentagyna*	A	21.9	1.3	1.1		*Litsea salicifolia*	A	22.8	1.2	3.6
	Tetracera sarmentosa	B	19.7	1.3	3.2		*Machilus villosa*	B	47.8	2.4	S
	Dioscorea belophylla	B	126.3	1.1	-		*Persea glaucescens*	C	32	1.7	0.7
Dioscoreaceae	*Dioscorea hispida*	A	270.2	1.7	-		*Persea odoratissima*	C	24.6	1.4	1.1
	Dioscorea pubera	B	112.3	0.9	-		*Phoebe lanceolata*	B	15.3	0.8	3.2
Diptrocarpaceae	*Shorea robusta*	B	77.2	4	27.6	Lecythidaceae	*Careya arborea*	B	33.3	2	7.9

Continued to Appendix 1.

Family	Scientific name	1	2	3	4	Family	Scientific name	1	2	3	4
	Leea compactiflora	B	73.7	0.7	-		*Gouania leptostachya*	B	210.5	3.7	-
Leeaceae	*Leea guineensis*	A	245.6	1.7	-	Rhamnaceae	*Ziziphus rugosa*	A	10.1	0.6	0.9
	Leea indica	A	319.3	1.9	-		*Ziziphus mauritiana*	A	6.1	0.3	1.3
	Lygodium flexuosum	A	9263.2	2.8	-		*Coffea bengalensis*	A	452.6	2.5	-
Lygodiaceae	*Lygodium japonicum*	A	6175.4	2.3	-		*Borreria ocimoides*	A	5719.3	2.4	-
	Lygodium microphyllum	A	1719.3	1.3	-		*Haldina cordifolia*	A	20.2	1.2	12.2
	Lygodium circinatum	A	1403.5	0.9	-		*Hedyotis scandens*	A	424.6	2.4	-
	Lagerstroemia parviflora	A	147.4	7.3	15.5		*Hyptianthera stricta*	A	9.6	0.6	7.4
Lythraceae	*Lagerstroemia speciosa*	C	29.4	1.6	14.2		*Ixora javanica*	A	14.9	0.9	6.3
	Duabanga sonneratioides	B	3.9	0.4	7.4		*Ixora nigricans*	A	10.1	0.7	5.7
Magnoliaceae	*Michelia champaca*	A	34.2	1.7	17.8		*Meyna spinosa*	B	16.7	0.9	-
Malvaceae	*Urena lobata*	B	49.1	0.5	-	Rubiaceae	*Morinda angustifolia*	B	14.9	0.8	5.7
	Abelncoschus Spp.	A	112.3	0.8	-		*Mussaenda roxburghii*	B	25.9	1.7	16.9
Marantaceae	*Schumannianthus dichotomous*	A	1929.8	0.9	-		*Neolamarikia kadamba*	A	9.6	0.6	7.4
Melastomataceae	*Mlastoma malabathricum*	A	52.6	4.3	-		*Oldenlandia stipulacea L.*	A	666.7	0.5	-
Menispermaceae	*Pericampylus glaucus*	A	308.8	1.91	-		*Psilanthus bengalensis*	A	168.4	1.1	-
	Tinospora cordiofolia	A	15.35	0.9	3.5		*Psychotria calocarpa*	A	20.6	1	1.4
	Cedrela toona	B	9.2	0.6	12.2		*Psychotria erratica*	A	171.9	1.4	-
Meliaceae	*Chukrasia tabularis*	B	30.3	1.6	12.5		*Uncaria scandens*	A	217.5	1.4	-
	Amoora wallichii	B	28.1	1.4	10.3		*Uncaria rusiacum*	A	49.1	0.5	-
	Swetenia mahogany	B	19.7	1.1	13.4		*Glycosmis pentaphylla*	A	59.6	0.5	-
	Artocarpus chama	B	14.9	0.8	6	Rutaceae	*Zanthoxylum rhetsa*	B	23.7	1.3	5.1
	Artocarpus chaplasha	A	18.4	1.1	6.5		*Aegle marmelos*	A	2.2	0.4	6.1
	Artocarpus lakoocha	B	13.2	0.8	5.6	Rhizophoraceae	*Carallia brachiata*	A	224.6	1.4	-
Moraceae	*Ficus hederacea*	B	171.9	1.3	-	Sabiaceae	*Meliosma pinnata*	B	20.6	1.1	3.6
Moraceae	*Ficus neriifolia*	A	0.4	0.1	36	Sapindaceae	*Aesculus assamica*	B	18.4	1.1	5.5
	Ficus religiosa	B	1.3	0.2	41.6	Sapotaceae	*Mimusops elengi*	A	21.5	1.2	4.7
	Streblus asper	A	1.75	0.3	3.53	Scrophulariaceae	*Lindernia ciliata*	A	7859.6	3.2	-
	Morus laevigata	A	1.7	0.3	3.5		*Ailanthus integrifolia*	A	8.3	0.6	8.9
	Ficus elastica	A	2.6	0.3	7.4		*Ailanthus grandis*	A	7.5	0.5	10
	Ardisia solanacea	A	186	1.4	-	Simaroubaceae	*Smilax aspericaulis*	A	77.2	0.7	-
Myrsinaceae	*Ardisia thyrsiflorus*	A	7	0.5	2.9		*Smilax ovalifolia*	A	42.1	0.6	-
	Maesa indica	A	5543.9	1.8	-		*Smilax perfoliata*	A	73.7	0.6	-
	Myristica eratica	A	3.5	0.2	7.4		*Ardisia solanacea*	A	17.5	0.9	2.9
	Myristica longifolia	A	4.8	0.4	8.3	Solanaceae	*Solanum khasianum*	A	7929.8	2.3	-
	Syzygium operculatum	A	16.2	0.9	7.4		*Solanum xanthocarpum*	C	8280.7	2.5	-
Myrtaceae	*Syzygium balsameum*	A	8.3	0.6	5.5	Sterculiaceae	*Pterygota alata*	B	157	8	5.9
	Syzygium claviflorum	B	9.2	0.8	4.7		*Sterculia villosa*	A	39	2.5	S
	Syzygium cumunii	A	25	1.3	15.4	Tetraceraceae	*Tetracera sarmentosa*	B	21.9	1.3	12.1
	Syzygium formosum	A	6.6	0.5	11.5		*Eurya cerasifolia*	B	4.8	0.4	2.6
	Eugenia cumini	A	7	0.5	2.6	Theaceae	*Schima wallichii*	B	28.5	2	11.9
Orchidaceae	*Bulbophyllum bailegi*	A	3052.6	1.2	-		*Eurya japonica*	B	1.3	0.2	2.6
	Phaus flavus	A	947.4	0.54	-		*Cyclosorus holttumii*	A	4701.7	2	-
Phyllanthaceae	*Bischofia javanica*	A	17.1	1.3	12.3	Thelypteridaceae	*Cyclosorus mantoniae*	A	4210.5	1.7	-
	Piper attenuatum	A	259.6	1.6	-		*Pronephrium nudatum*	A	6350.9	2.1	-
Piperaceae	*Piper peepuloides*	A	326.3	2	-	Ulmaceae	*Trema orientalis*	A	2.6	0.8	7.4
	Piper sylaticum	A	119.3	0.9	-	Urticaceae	*Dendrocnida sinuata*	A	371.9	2.1	-
Plantaginaceae	*Lindernia crustacean*	B	8771.9	2.6	-		*Callicarpa longifolia*	A	217.5	1.3	-
	Acroceras zizanioides	A	6175.4	2.2	-		*Callicarpa tongifolia*	A	207	1.2	-
	Angiopteris evecta	A	11824.6	3.2	-		*Clerodendrum chinense*	A	242.1	1.5	-
	Axonopus compressus	A	11193	3.3	-	Verbenaceae	*Clerodendrum viscosum*	A	266.7	1.5	-
	Brachiaria milliformis	A	6280.7	2.4	-		*Gmelina arborea*	A	36	3.4	15.6
Poaceae	*Capillipedium assimile*	A	2771.9	1.1	-		*Tectona grandis*	C	172.8	8.7	24.4
	Saccharam spontaneum	A	912.3	0.5	-		*Vitex quinata*	B	2.2	0.4	4.7
	Degitaria cilliaris	A	3789.5	1.6	-		*Lantana camara*	A	343.9	2	-
	Neomicrocalamus andropogonifolius	A	4.4	0.8	-		*Ampelocissus sp.*	A	161.4	1.1	-
	Pennisetum purpureum	A	2877.2	1.2	-		*Cayratia trifolia*	A	70.2	0.7	-
Polypodiaceae	*Colysis decurrens*	A	3649.1	1.6	-	Vitaceae	*Cissus repens*	A	6666.7	2.4	-
Polygonaceae	*Polygata glomerata*	A	6666.7	2.2	-		*Tetrastigma campylocarpum*	A	252.6	2.2	-
	Pteris biaurita	A	13403.5	3.5	-		*Tetrastigma serrulatum*	A	305.3	1.5	-
	Pteris himalayensis	A	10736.8	3	-		*Alpinia nigra*	A	1824.6	0.9	-
Pteridaceae	*Pteris linearis*	A	8701.7	2.5	-	Zingiberaceae	*Globba macroclada*	A	2491.2	1	-
	Pteris aspericaulis	A	13403.5	37.9	-		*Globba racemosa*	A	4421	1.6	-
	Pteris semipinnata	A	5438.6	2.2	-		*Hedychium coccineum*	A	5543.9	2	-
Ranunculaceae	*Naravelia zeylanica*	A	52.6	0.5	-	Unidentified	52 species (29 trees species)	A	1.3-7087.7	0.2-2.6	2.2-11.4

Note: 1. Frequency class 2. Density (individuals/ha); 3. IVI; 4. Basal area (m^2/ha), S- seedling